G H Starr o Riedl.
227

BULLETIN NO. 270 APRIL, 1945

UNIVERSITY OF WYOMING AGRICULTURAL EXPERIMENT STATION

The first noticeable symptom in a potato plant infected with ring-rot—the light green to grayish spots in the leaves. Some of the leaves have begun to wilt and roll up.

Potato Ring-Rot and Its Control

IMPERIAL MYCOLOGICAL
11 JAN1946
INSTITUTE

Bulletins will be sent free upon request.
Address: Director of Experiment Station, Laramie, Wyoming.

UNIVERSITY OF WYOMING
Agricultural Experiment Station

BOARD OF TRUSTEES

Officers:

Milward L. Simpson.....President — P. M. Cunningham.....Treasurer
Tracy S. McCraken.....Vice President — Fay E. Smith...Comptroller and Secretary

Executive Committee:

MILWARD L. SIMPSON, Chairman.....Ex Officio
JOSEPH R. SULLIVAN — P. M. CUNNINGHAM — TRACY S.McCRAKEN

Appointed	Members	Term Expires
1939	MILWARD L. SIMPSON—Cody	1951
1941	HAROLD M. JOHNSON, Rawlins	1947
1941	MARY EDELMAN COPE—Torrington	1947
1943	EARLE G. BURWELL—Casper	1947
1943	TRACY S. McCRAKEN—Cheyenne	1949
1943	P. M. CUNNINGHAM—Cheyenne	1949
1943	A. L. KEENEY—Superior	1949
1945	JOSEPH R. SULLIVAN—Laramie	1951
1945	H. D. WATENPAUGH—Sheridan	1951

LESTER C. HUNT, Governor of Wyoming.....Ex Officio
ESTHER L. ANDERSON, State Superintendent of Public Instruction.....Ex Officio
JAMES LEWIS MORRILL, LL.D., President of the University.....Ex Officio

STATION STAFF

Administration

J. A. HILL, B.S., Dean of College of Agriculture; Director of Station.
W. L. QUAYLE, B.S., Director Experiment Farms.
JOSEPHINE McCUE, B.A., Station Clerk.

Agronomy and Agricultural Economics:

A. F. VASS, Ph.D., Agronomist.
T. J. DUNNEWALD, M.S., Assoc. Soil Investigations.
G. H. STARR, Ph.D., Agronomist; Plant Pathologist.
W. A. RIEDL, M.S., Assoc. Agronomist.
†EDWARD J. TALBOT, M.S., Asst. Economist.
ROBERT LANG, M.S., Asst. Agronomist.
†JOHN F. CYKLER, B.S., Asst. Agricultural Engineer.
DAYTON KLINGMAN, M.S., Asst. Agronomist.
†ROICE H. ANDERSON, Ph.D., Asst. Prof.; Research Asst., Agricultural Economics.
LAEL R. HARRISON, B.S., Research Asst. in Agronomy.

Animal Production:

FREDRIC S. HULTZ, Ph.D., Animal Husbandman, Sheep, Beef Cattle.
S. S. WHEELER, Ph.D., Animal Husbandman, Beef Cattle, Swine.
H. S. WILLARD, Ph.D., Animal Husbandman, Dairy Cattle.
†J. A. GORMAN, M.S., Asst. Animal Husbandman, Horses, Sheep.
LAWRENCE MORRIS, Ph.D., Assoc. Animal Husbandman, Poultry.

Apiculture and Entomology:

ROBERT E. PFADT, M.S., Asst. Research Entomologist.
*A.P. STURTEVANT, Ph.D., Apiculturist, in Charge of U. S. Bee Culture Field Laboratory.
*C. E. BURNSIDE, Ph.D., Apiculturist.
*I. L. REVELL, A.B., Junior Apiculturist.
†*J. D. HITCHCOCK, M.A., Junior Apiculturist.

Chemistry:

O. A. BEATH, M.A., Research Chemist.
C. S. GILBERT, M.A., Assoc. Research Chemist.
†H. F. EPPSON, M.S., Asst. Chemist.
IRENE ROSENFELD, Ph.D., Asst. Pharmacologist.
K. F. SWINGLE, Ph.D., Asst. Research Chemist.

Home Economics:

ELIZABETH J. McKITTRICK, M.S., Home Economist.
EMMA J. THIESSEN, M.A., Assoc. Home Economist.

Library:

MARY E. MARKS, Ph.B., Librarian.

Veterinary Science and Bacteriology:

A. M. LEE, D.V.M., M.S., Research Pathologist.
J. F. RYFF, D.V.M., Assistant Veterinarian.

Weather:

FRANK E. HEPNER, M.S., Head of Weather Station.

Wool:

J. A. HILL, B.S., Wool Specialist.
ROBERT H. BURNS, Ph.D., Wool Specialist.

Zoology:

JOHN W. SCOTT, Ph.D., Zoologist and Parasitologist.
†RALPH HONESS, M. A., Asst. Research Zoologist.

*In cooperation with U. S. Department of Agriculture. †On leave.

OCT 1948

Potato Ring-Rot and Its Control

By G. H. Starr and W. A. Riedl

INTRODUCTION

Bacterial ring-rot of potatoes caused by **Corynebacterium sepedonicum** continues to to be an important disease problem in potato production. Although losses from this disease have been greatly reduced within the past few years, recent surveys show that ring-rot losses are again increasing in many parts of the United States. Thus, all possible precautions should be taken to hold these losses to an absolute minimum.

In recent years, considerable work has been done in Wyoming to obtain information that would be helpful in the control of ring-rot. This work included methods of spread, identification and three general types of control which are reported herein, as follows: (1) **disease-free seed,** together with methods of keeping it free from ring-rot, as well as other diseases; (2) methods of **sanitation** and **disinfection,** including the testing of numerous disinfectants for the various phases of ring-rot control; (3) **varietal resistance,** which involved the testing of many varieties and seedlings in the search of ring-rot resistant potatoes. Specific control recommendations based on the results of this research are also given.

Figure 1. Potato plant showing an advanced stage of ring-rot. The lower leaves are rolled and brown, while the upper ones are just beginning to wilt. Often the disease advances so rapidly that some of the leaves are in a wilted condition and still green.

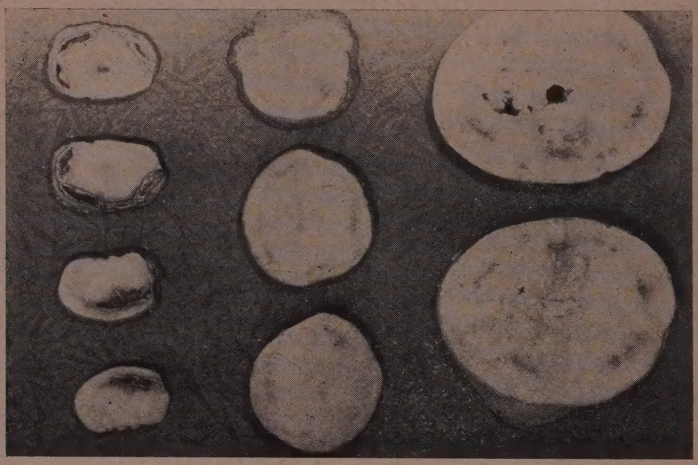

Figure 2. Cross-sections of three tubers showing the depth of penetration of ring-rot infection. In addition, the slices on the left have dry, brownish rots in the vascular area caused by molds or fungi. The sections on the right show the bacterial ooze squeezed from the vascular rings. These pieces are also infected in the central portion with soft-rot.

SYMPTOMS

The first noticeable symptom, at least in the Bliss Triumph variety, is the appearance of light green to grayish spots on the leaves, (Figure on cover page). Shortly after this symptom appears the leaves begin to wilt. This wilting develops rapidly, beginning in the lower branches and progressing upward until the whole plant is wilted. Often the wilting is so rapid that numerous leaves are wilted while they are still green, (Figure 1). It requires from 55 to 80 days from planting time for ring-rot symptoms to appear, depending on the soil temperature. Because the symptoms develop late in the season, a high percentage of marketable tubers carries the infection. Infected tubers show a yellowish to creamy discoloration in the vascular ring of the tuber, hence, the name "ring-rot." This region is filled with innumerable bacteria, which may be readily squeezed out as an oozy material if the tubers have been in storage for some time, (Figure 2). In advanced stages the combination of ring-rot bacteria and soft-rot bacteria often causes a rapid breakdown in the central portion of the tuber, so that occasionally only a hollow shell remains; in most cases, however, the whole tuber is a mass of soft-rot. Occasionally, molds or fungi are present in the vascular ring along with the ring-rot bacteria, resulting in a rather dry, brownish rot localized in this area, (Figure 2). Under irrigation, tuber breakdown is more common than un-

der dry-land conditions, probably because the conditions are more favorable for the soft-rot bacteria.

METHODS OF SPREAD

Ring-rot has become a serious disease primarily because of its infectious nature. Any process that brings ring-rot bacteria in contact with potato tubers is likely to cause infection.

Cutting knife—The most common method of spread is in the cutting process. It has been found that as many as 25 tubers may be infected after the knife is contaminated with ring-rot bacteria.

Sacks, baskets, sorters, etc.—Experimental tests have shown that ring-rot bacteria may live for several months in the storage cellar. Sacks, sorters and baskets that come in contact with these bacteria may spread them to healthy potatoes later sorted or handled with this equipment. Contaminated sacks are believed to be an important means of spread of ring-rot bacteria.

Planters, diggers, etc.—Potato planters, when used to plant diseased seed, may become contaminated with the bacteria and can spread them to healthy lots of seed planted later with this machinery. This type of spread has been observed where farmers have finished planting diseased seed in one field and have gone directly into another field planted with healthy seed. The picker type of planter is believed to cause more spread of ring-rot than the assisted-feed type. The picks, after piercing infected seed pieces, are likely to introduce the bacteria into a number of healthy seed pieces subsequently picked up by them.

Ring-rot bacteria may also be spread by the digger but in all probability it is not so important as the planter.

Insects—It has been reported that ring-rot can be spread by certain insects; namely, Colorado potato beetles, grasshoppers and black blister beetles. Other insects may be involved but this source of spread is not considered important at the present time.

Soil—Considerable work has been done on the over-wintering of the causal organism in the soil. There is little or no evidence that the bacteria can survive in soils in this area during the winter months.

METHODS OF IDENTIFYING RING-ROT

Ring-rot may be identified by certain symptoms or by the use of special methods, which are as follows: (1) plant symptoms, (2) bacterial ooze in stems and tubers, (3) gram-positive stain and (4) the ultra-violet lamp.

1. Plant symptoms are usually quite typical if the plants are infected alone with ring-rot; however, if other diseases are

combined in the same plant, the symptoms are not likely to be characteristic. Typical symptoms are described earlier in this bulletin. If ring-rot alone is present, the lower stems, both externally and internally, will appear to be perfectly healthy, while some other diseases will show certain characteristic symptoms.

2. Plants infected with ring-rot have a large accumulation of bacteria in the stems just above the seed pieces. If such stems are cut off near their points of attachment to the seed pieces, a milky ooze can be squeezed out of them, which is indicative of ring-rot. This method has been used for the past five years by seed certification inspectors in Wyoming as an aid in identifying the disease and it is considered quite accurate. As previously mentioned, tubers infected with ring-rot, and especially those that have been in storage for some time, upon being squeezed near the cut surface, will exude a yellowish to grayish bacterial ooze from the vascular ring, indicative of ring-rot. However, this oozy material cannot be squeezed out of tubers having but slight infection.

3. The most accurate method of diagnosing ring-rot is that of staining the causal bacteria and identifying them by means of a microscope. This is especially true if the bacteria are taken from infected potato stems. Tubers badly broken down with soft-rot are difficult to test for ring-rot and even this method is not always reliable under such conditions. Ring-rot bacteria are of typical size and shape and are stained a deep blue with certain gram-positive stains. Moreover, they are usually very abundant in infected stems and tubers.

4. Tubers infected with ring-rot, when placed under an ultra-violet lamp, (after the stem-end portion has been freshly cut off) will exhibit on the cut surface a characteristic type of fluorescence. Wounds, bruises and other types of defects also give a fluorescence similar to that given by ring-rot. Although this method may not be practical for the average grower, an experienced technician can become highly efficient in diagnosing the disease. This method has been used in certain potato areas in order to reduce infection in commercial lots of seed.

In identifying ring-rot it is desirable to base the diagnosis upon a combination of these methods. Although the stain method is considered most accurate, it should not be depended upon entirely for all ring-rot determination. Any one method may be sufficient in certain cases, but it is felt that a combination of them should be used for a definite diagnosis of ring-rot.

Figure 3. An irrigated field of certified potatoes, free from ring-rot. This is the result of using the best seed obtainable.

CONTROL

A. DISEASE-FREE-SEED PROGRAM—The use of seed free from ring-rot is the best control method that can be used. Certified seed insures the best quality crop, not only from the standpoint of freedom from ring-rot, but also from other diseases as well, (Figure 3). In order to prevent diseases in general from increasing in even good seed, certain practices must be followed to keep that seed healthy. The following methods are described:

1. **Hill-indexing and unit planting**—Hill-indexing is the testing of separate hills, usually in a greenhouse during the winter months, to determine whether they are healthy or diseased, (Figure 4). First of all, 100 or more vigorous, healthy-appearing hills are selected in the field and staked a short time before maturity, while the plants are still green. (No hills should be selected that are near diseased hills). Paper or cloth bags, to be used for storing the separate hills, should be clearly numbered in consecutive order. Small bags also should be numbered to correspond with the hill bags. Just before the field is harvested, these hills are dug and sacked separately. If any of the hills have tubers of poor type or appear to be diseased, they should be discarded. From two to four small tubers, one inch or more in diameter, should be selected from each hill and placed in the small bag numbered the same as the hill container. (This can be done at digging time or after the potatoes are

Figure 4. Potatoes in one of the greenhouse benches planted during the winter months to detect disease in tuber- and hill-units. Members of the University staff in charge of the potato improvement work are rechecking the plants before discarding them. The first check-up is made when the plants are from 8 to 12 inches tall. One entire greenhouse is utilized for this type of work.

placed in storage). When harvesting is completed, these bags are stored preferably in a location where they will not be disturbed and where there will be no chance of mixture with other potatoes.

The small tubers are to be sent to the University of Wyoming, where they will be grown in a greenhouse to be tested for disease. The diseased units will be reported, by number, to the grower who can then discard them before planting time. Thus, diseased units will be eliminated and not planted with the healthy ones in the seed plot. At planting time each hill-unit is cut to make as many seed pieces as possible. The cutting knife should be disinfected between each hill cut, (B-2 under "Control"). These units are then planted, preferably with an assisted-feed planter or dropped by hand, leaving a space of six to ten feet between units. The plants should be inspected carefully during the summer for disease and for units of earlier maturity than the average. Such units should be rogued out entirely as soon as they are found. The units should be harvested separately in clean sacks and they should be left in these sacks during storage. The following year, these units again should be separated by a space in the row. The plot should be inspected carefully during the summer and rogued as suggested above. The remaining healthy units can be combined at har-

vest time. They should be planted by the tuber-unit method in a well-isolated field the following year, (Figure 5).

2. **Tuber-indexing and unit planting**—Tuber-indexing is similar to hill-indexing, except that tubers instead of hills are selected and tested. Here, a seed piece is cut from each tuber, (preferably at the stem-end), numbered to correspond with that of the tuber, and planted in the greenhouse. The plants are carefully inspected and those found to be diseased are recorded by number. All tubers having corresponding numbers are discarded. The remaining tubers are cut into four or more seed pieces and planted in units separated by a space of three to five feet. These units are rogued carefully during the summer and can be combined at harvest time, (Figure 6).

In the past, hill-indexing and tuber-indexing methods have been used primarily for the elimination of virus diseases. Recently, the former method has been used successfully in the elimination of ring-rot, as well.

3. **Field roguing**—The removal of all abnormal plants in a field will tend to eliminate diseased plants and thus prevent a rapid increase in total disease.

This method will not eliminate ring-rot entirely from infected fields as certain plants may not show definite symptoms but will still carry bacteria in sufficient quantity to cause ring-rot in next year's crop. If ring-rot should develop in a field,

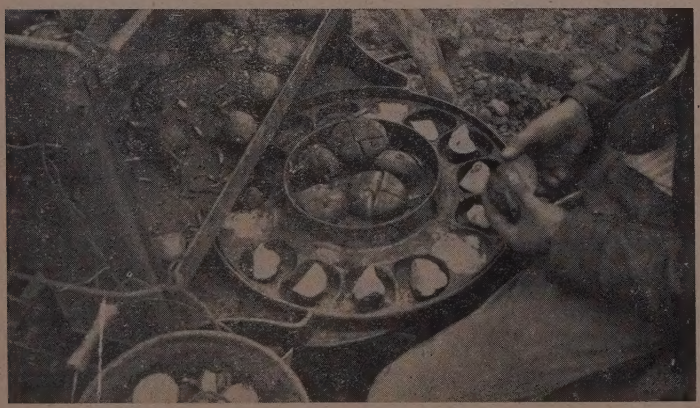

Figure 5. Tuber-units being planted by an assisted-feed planter. The tubers of certain size are partially cut into four seed pieces, then broken apart just before planting and placed consecutively in the openings of the revolving wheel with one space left between each tuber-unit. These four-hill units aid in the roguing process later on.

Figure 6. Showing a portion of the foundation seed plot on the Odin Holgerson farm near Albin. The Holgersons, in the foreground, are observing the tubers from a four-hill unit. In the background, hills that were previously staked, are being dug and sacked.

roguing should be practiced to remove as much of the disease as possible. Since not all tubers show ring-rot symptoms, they can be more completely removed in the field than they can be in the bin. Roguing will help to reduce losses in storage and in shipment, although it is not practical to rogue fields containing considerable ring-rot.

B. SANITATION AND DISINFECTION—When ring-rot is found in certain lots of seed, definite precautions must be taken in order to get rid of it completely. A general clean-up or a sanitation program is the first step, followed by thorough disinfection, (Figure 7). These are described in the following five subtopics:

1. **Seed disinfection**—The purpose of seed disinfection is to kill ring-rot bacteria and accompanying bacteria that may be present on the surface of tubers and seed pieces. It will not kill bacteria present within the tuber or seed piece.

a. For **whole** seed, corrosive sublimate (1:500 or 4 ounces to 15 gallons of water) is recommended for a treating period of 20 to 30 minutes, or acid-mercury (Mercurnol) is equally effective when used according to directions for a period of 3 minutes. Small seed, that does not have to be cut, is advantageous in that there is no chance of ring-rot spread by the cutting knife. However, if such seed con-

Figure 7. A portion of the ring-rot test plots in midsummer at the Agronomy Farm near Laramie in 1942. The central portion, with missing units, shows the test dealing with ring-rot resistance. Many of the susceptible varieties and seedlings were killed out early by ring-rot. The remainder of the plot shows the experiments in which many chemicals were tested as disinfectants for ring-rot bacteria on the cutting knife, in the cellar and on the seed, as well.

tains spindle tuber or other virus diseases, there is likely to be a substantial increase in those diseases.

b. For **cut** seed, corrosive sublimate (1:500 or 4 ounces to 15 gallons of water) is recommended for a treating period of 15 minutes. If a 1:1000 solution is used (4 ounces of corrosive sublimate to 30 gallons of water) the treating period should be increased to 30 minutes.

When seed is treated after being cut, it should be planted immediately, while still wet. If this cannot be done, the seed should be spread out in thin layers to dry; otherwise, it is likely to heat and may result in a poor stand.

2. **Knife disinfection**—The best way to disinfect the cutting knife is by the use of boiling water. Both a stationary and rotary knife can be disinfected effectively in this manner. A rotary knife running in boiling water is kept disinfected at all times and is very effective in keeping down ring-rot spread through the cutting process. Boiling water will actually kill ring-rot bacteria in about 10 seconds. Plans for such a rotary

knife are available upon request, (Figure 8). Where heating equipment is not available, corrosive sublimate may be used in a 1:500 solution or 4 ounces to 15 gallons of water. Corrosive sublimate corrodes metal and so must be used in nonmetallic containers.

3. **Sack disinfection**—Steam is recommended for the disinfection of sacks where it is available and can be used under pressure. Exposing sacks for a few minutes to steam at 5 to 10 pounds pressure should be sufficient to kill all ring-rot bacteria. When sacks are to be disinfected they should not be fastened together tightly in a bale as the steam may not be effective in the interior portion unless under considerable pressure and for a prolonged period of time. Copper sulphate (1 pound to 10 gallons of water) also is recommended, especially for used bags, if the discoloration of the bags is not considered as impairing their value. In using copper sulphate, the bags should be soaked in the solution for a few minutes, the excess liquid drained off and the sacks spread out to dry. If formaldehyde is used, the bags should be soaked in the solution (1 pint to 15 gallons of water) until thoroughly wet, then drained off and

Figure 8. A power-driven rotary cutting knife equipped with two blades designed to run continuously in a vat of boiling water or in a disinfectant solution. The conveyor bands at either side of the blades also run through the solution in the vat and are kept disinfected. This machine is similar to those used extensively in some commercial potato areas.

covered for one hour or more in order to allow sufficient time for the fumes to act. Later, they can be spread out to dry. **Acid-mercury (Mercurnol) or any other acid solution should not be used on burlap or cloth material.** Sack disinfection often results in prolonged life of the bags.

4. **Cellar sanitation and disinfection**—First of all, cellars should be cleaned out completely of any old or rotten potatoes that may be present. In the disinfection process, the bin boards, floor and all surfaces that have come in contact with potatoes should be sprayed thoroughly with (1) copper sulphate (2 pounds to 10 gallons of water) **or** (2) Lysol (1 per cent solution or 1 quart to 25 gallons of water) **or** (3) formaldehyde (1 pint to 15 gallons of water). Formaldehyde is unpleasant to use in this manner but when used, the cellar should be closed for one or two days, after which it can be opened and ventilated.

5. **Disinfection of equipment**—Equipment such as sorters, planters, diggers and baskets can be disinfected by the use of (1) copper sulphate (2 pounds to 10 gallons of water) **or** (2) Lysol (1 per cent solution or 3 tablespoons per gallon of water or 1 quart to 25 gallons of water). Formaldehyde should not be used on equipment unless used inside where the fumes can be confined.

Figure 9. A portion of the plot where varieties and seedlings were being tested for ring-rot resistance. W. A. Riedl is pointing out a resistant seedling, to his left, and the susceptible Bliss Triumph check, to his right.

C. RESISTANT VARIETIES—The most effective way to control disease is by the use of resistant varieties. Highly resistant varieties are difficult to find, thus, the necessity of a long-time testing program of this type. During the past five years 26 commercial potato varieties and approximately 2,000 potato seedlings have been tested for ring-rot resistance at the Wyoming Experiment Station, (Figures 7 and 9).

The method used in testing for ring-rot resistance consisted of smearing the cut surfaces of the seed pieces with bacterial ooze from ring-rot infected tubers, then submerging the seed pieces in a suspension of bacterial ooze made from infected tubers. The seed pieces were planted immediately after being inoculated. Readings for ring-rot symptoms were made during the growing season. The stems and tubers from plants showing no symptoms were saved at harvest time and were checked for ring-rot by the ultra-violet lamp and by the gram-stain method. All the commercial varieties tested were found to be highly susceptible, containing from 24 to 100 per cent infected plants. Less than one per cent of the seedlings tested showed no ring-rot symptoms. Those seedlings testing free from ring-rot, both in the vines and tubers, were again inoculated and planted the following year in more extensive trials along with inoculated checks of the Bliss Triumph variety planted every tenth row for comparison.

Thirteen potato seedlings have not shown any ring-rot symptoms in the vines or tubers in five years of testing. Some of these have commercial quality and are being increased. One seedling, Wyoming 27 (U.S.D.A. 47102), has been increased to 2,000 bushels at the present time. This potato is white-skinned, medium-late in maturity and has good-cooking and keeping qualities. It has been tested in variety-yield trials in Wyoming, Colorado and Maine and was found to be relatively high in yield. In 1945 this seedling will be grown at several locations in this state, as well as in other states and Canada, to secure further information on its adaptation. If it proves to be adapted and commercially desirable, it will be given a variety name.

Potato breeding work is being continued in an effort to develop more ring-rot-resistant varieties and to determine the nature of the resistance that these potatoes have to ring-rot.

RECOMMENDATIONS FOR RING-ROT CONTROL

A. Where grower does not have ring-rot and uses preventive measures to keep seed free from it.

1. Disinfect seed, (B-1 under "Control").
2. Clean out cellar and disinfect it, (B-4).
3. Do not store potatoes from other growers in cellar.
4. Caution visitors or buyers not to cut tubers with knife that may be contaminated with ring-rot bacteria from a neighbor's potatoes.
5. Do not lend or borrow planters, diggers, sorters, picking bags or any other equipment as ring-rot may be introduced in this manner.
6. Do not obtain new lots of seed potatoes from other growers or from other states just to see what they are like. Ring-rot as well as other diseases may be introduced.
7. Arrange to have a seed plot and rogue it thoroughly, (A-1, 2 and 3).
8. **When you once get good seed, do your utmost to keep it good. Do not obtain other seed of unknown merit.**

B. Where grower has ring-rot and is attempting to eliminate it completely.

1. Dispose of entire potato crop infected with ring-rot. (Do not keep a portion of this seed and at the same time buy new seed if you wish to eliminate ring-rot).
2. Clean out cellar, clean up equipment, then disinfect both thoroughly, (B-4 and 5).
3. Obtain the best certified or foundation seed available.
4. Bring in such seed just before planting time, so that it will not be stored in a cellar where ring-rot was present the previous year.
5. If necessary to store new seed, place sacks on new or well-disinfected boards until planting time. If possible, prepare seed for planting outside of cellar.
6. Disinfect seed, (B-1).
7. Do not borrow planting equipment unless disinfected before being used. (B-5).
8. Let cellar dry out well during summer.
9. Do not store other potatoes of unknown ring-rot content in your cellar.

SUMMARY AND CONCLUSIONS

Bacterial ring-rot continues to be an important problem in potato production and according to surveys is even increasing in many parts of the United States. All possible precautions should be taken to keep down ring-rot losses.

The first noticeable symptoms are light green to grayish spots on the leaves, followed by a rapid wilting, which begins in the lower branches and progresses upward in the plant. Infected tubers first have a yellowish discoloration in the vascular ring and if other organisms are present, tubers eventually may be completely rotted.

The disease is highly infectious and spreads readily by contact, especially through the cutting knife, containers, equipment and machinery.

Ring-rot is identified by: (1) plant symptoms, (2) bacterial ooze in stems and tubers, (3) the gram-positive-stain method and (4) the ultra-violet lamp. Any of the above may be sufficient for ring-rot detection but it is felt that a combination of them should be used for absolute identification.

The three general methods of control are: (1) **disease-free seed,** (2) **sanitation** and **disinfection** and (3) **varietal resistance.**

1. Disease-free seed is recommended and hill-indexing, tuber-indexing and field roguing are methods suggested to keep seed healthy.

2. Seed treatments are recommended to reduce ring-rot spread through the seed and through the cutting knife. Disinfection of used sacks, sorters, and other equipment is urged, as well as sanitation and disinfection of the storage cellar.

3. Varietal resistance is discussed as an effective long-time program. All commercial varieties are susceptible in varying degrees to ring-rot but several seedlings have been found which have not contracted the disease after five years of testing in ring-rot-resistance trials. Notably among these is Wyoming 27 (U.S.D.A. seedling 47102). This seedling has been increased to 2,000 bushels at present and is available for those desiring it for trial. Several resistant seedlings have been found which require additional testing to determine their adaptation and commercial desirability.

Detailed recommendations are given, enabling growers to keep their seed free from ring-rot and to eliminate it where present.

Remember, seed is the main consideration in ring-rot control; get the best seed and try to keep it good.